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Environmental Enrichment Program for Serial Probe Recognition (SPR) Trained *Macaca mulatta*

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In an effort to insure that a physically and mentally stimulating environment is provided for social animals in captivity, the establishment of an enrichment program for primates was mandated by Congress in the Amendment to the Animal Welfare Act, 1985.

The function of the primate environmental enrichment program implemented by the Advanced Assessment Branch of the Drug Assessment Division is to provide for the psychological well-being of Rhesus monkeys being trained in a serial probe recognition (SPR) task. An effective enrichment plan improves the psychological as well as the physiological health of primates. The nonhuman primates must be in good physical health and express a substantial range of species-appropriate behaviors. A plan should incorporate devices that require the use of all the senses: tactile, visual, olfactory, auditory and gustatory (Mahoney, 1992). Enrichment devices must also promote foraging and locomotor behaviors as these are primary behaviors in non-captive nonhuman primates. An enrichment program is best evaluated by examining the physical health, behavioral repertoire, stress, and coping skills of the primates maintained in the program (Novak & Suomi, 1991). A variety of enrichment strategies should be used to identify those strategies that best promote psychological well being in Rhesus monkeys allowing the most efficient allocation of resources. An effective enrichment plan requires the joint effort of investigators, technicians, veterinarians and caretaker staff.

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Introduction

An animal's behavior is influenced by the evolutionary history of its species. Ecological influences on social behavior are a function of individual histories in response to the environment. The social organization of a group is determined by the content, quality and pattern of relationships between group members (Nagel, 1979). Changes in group size as well as intergroup and intragroup dynamics are determined by long-term shifts in demographic patterns and social relationships. Primates engage in complex social behaviors. Researchers have shown that in nonhuman primates, skills such as recognizing other members in the colony and behaving differently to those members according to the dominance hierarchy are learned and continue to develop with experience (Essock-Vitale & Seyfarth, 1987). Opportunities to perform these complex social behaviors preserve their integrity.

In an effort to provide a physically and mentally stimulating environment for social animals, the establishment of an enrichment program was mandated by Congress in the Amendment to the Animal Welfare Act, 1985. Researchers were made legally responsible for providing for the "psychological well-being" of these animals. To date, however, the scientific community has not fully standardized the new terminology created in this amendment.

In the present study, physical health, behavioral repertoire, and coping skills were used to evaluate daily the well-being of the nonhuman primates training on the Serial Probe Recognition Task. Primates were in good physical health and expressed species-appropriate behaviors such that individually caged animals did not perform bizarre or disorganized patterns of behavior. Secondly, the animals showed no clinical or behavioral signs of chronic distress as described by Novak et al., 1988 (Appendix A). Primates were, therefore, able to respond effectively to environmental challenges (Mench, 1994).

Materials and Methods

Animals

Nineteen male rhesus monkeys (Macaca mulatta), from Laboratory Animal Breeder and Services (LABS, Yemassee, SC), and six females and two males, from the Delta Primate Center at Tulane University (Covington, LA), were being trained on the SPR task. Upon arrival, all animals were quarantined and screened for evidence of disease. All primates were tested quarterly for tuberculosis and received a complete physical examination twice a year. All housing conditions and veterinary care given to the monkeys were in accordance with the "Guide for the Care and Use of Laboratory Animals" (U.S. Department of Health and Human Services, 1985) in an AAALAC-accredited facility. At the time they were placed on the study, the animals ranged in age from four to eight years. They were singly housed in 61 cm W X 71 cm D X 86 cm H stainless steel, squeeze-backed cages configured in banks of four cages (Allentown Caging Equipment Co., Inc., Allentown, NJ). When cages were changed, animals from the bottom cages were placed on the top, and animals on the top were placed in the bottom cages. The cages were cleaned daily and complete cage changes were biweekly. Animal rooms were maintained in a temperature-controlled (20 - 22 °C) and humidity-controlled (50 % ± 10%) environment with at

least 10 complete air changes of 100% conditioned fresh air per hour. The animals were on a 12-hour light/dark cycle with no twilight (lights on at 0600). Nonhuman primates were fed twice per day with a commercial primate chow (Certified Primate Chow, Purina Mills, Inc., St. Louis, MO). They received fruit (bananas, apples, oranges, grapes) twice per day, and water was available *ad libitum*. Each animal received 190 mg of primate precision pellets (Bioserve, Inc., Frenchtown, NJ) daily. Animals were maintained on 110 Kcal/kg/day until age eight at which time they were placed on 75 Kcal/kg/day. All animals were taught to drink from either a 60 ml catheter-tipped syringe or a squeeze bottle in order to receive orange flavored drink, applesauce or fruit juice.

Serial Probe Recognition Task Training

All animals were trained on the Serial Probe Recognition (SPR), a computerized operant behavioral task that measures memory, decision making and sensory integration (Castro et al., 1992). Once a day, the animals were placed unrestrained in an assigned SPR chamber. The SPR software program allowed each animal to progress at its own pace. Initially SPR technicians assisted with the training. Once animals worked independently, their progress was monitored daily until research testing commenced. SPR training also constituted an enrichment because placing the animals in the SPR chamber provided a change of environment.

Social Enrichment (Pair Housing)

To reduce isolation, pair housing was attempted. Six animals were involved in this portion of the enrichment program, four males and two females. Age and rearing histories were evaluated before compatible pairs were selected. During the pairing procedure, a veterinarian was always available in the event an injury occurred. The first step in the pairing process was to place individual animals in separate sections of a neutral cage to prevent any territorial antagonism. A solid metal panel that separated the cages was replaced with a Plexiglas panel. The Plexiglas allowed for visual but not physical interaction (non-contact familiarization). The Plexiglas panel was replaced by the stainless steel panel at the end of the day. When aggressive behaviors ceased and no abnormal behaviors (Table 1) indicative of some degree of distress occurred. The Plexiglas panel was replaced with a small bore screen. This screen allowed the animals minimal contact with each other using the tips of their fingers. The panel was eventually replaced by a large bore screen. The size of this bore allowed the animals to groom each other. During full contact pairing, the large bore screen was partially removed after the technician determined that the animals had established a dominance hierarchy. A staff veterinarian was available when the large screen was introduced and during full contact pairing.

TABLE 1

Abnormal Behaviors

Self-Directed	**Attitude**	**Environment-Directed**
hair-pulling	depression	pacing
self-biting	hypoactivity	spinning
self-grasping		bouncing
eye-poking		hyperactivity
self-slapping		somersaulting
head-banging		rocking
saluting		circling
self-orality		cage-biting
auto-erotic stimulation		coprophagia
		urine-drinking
		hyperphagia
		hyperaggression
		polydipsia

Human/Animal Interactions

Serial Probe Recognition animals spent the majority of their day in close proximity to humans. Each animal was moved, using a transport cage, from its home cage to a weighing scale and then to the SPR chamber. At the completion of SPR training/testing the animals were returned to their home cages and given the opportunity to select their favorite enrichment foods, such as peanuts, PrimaTreats (Bioserve, Frenchtown, NJ), or marshmallows, from a mixture in a large bucket. The animals were also given treats by hand from the technician on a daily basis. These treats given on alternating days, consisted of an orange-flavored vitamin or a five-gram PrimaTreat (Bioserve, Frenchtown, NJ). Hand treats were delivered by the technicians, who held the treats in their hands and allowed the animals to retrieve it. Daily meals were delivered by allowing animals to choose their biscuit and fruit ration from a bucket.

Enrichment Devices

Non-Social (temporary enrichment devices)

Non-social temporary devices were items that the animals received for less than two days and did not involve interaction with the technicians or other animals. These devices frequently were light enough for the animal to carry (Figure 1). All animals received two temporary enrichment devices each day (Table 2). When an animal showed a preference for a particular item, the item was labeled with the animal's identification number. This marked item remained with the animal as a permanent enrichment device. The device was cleaned when cage transfers were performed and then returned after being run through the cage wash. Unless the animal exhibited abnormal behavior, the enrichment would include one device with food spread on the outside or food implanted within it. An additional device with or without food was also

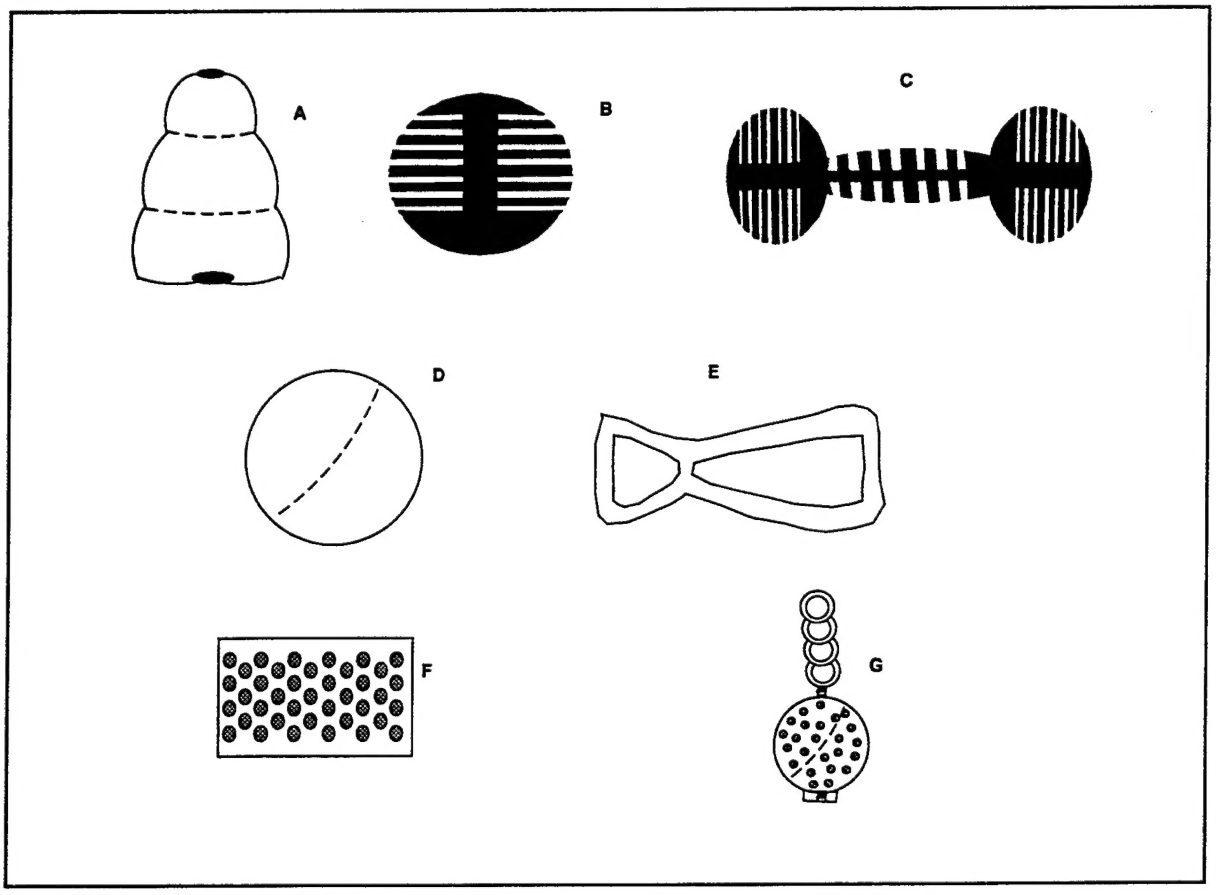

Figure 1. Drawings of devices used in the environmental enrichment program. **A.** Kong toy, **B.** Orbit ball, **C.** Orbit dumb bell, **D.** Nylon ball, **E.** Pull toy, **F.** Raisin board, **G.** Nylon ball on chain.

given. Placement of these temporary devices was usually performed when the animal was removed from the home cage for daily SPR training. No more than two temporary devices were placed in an animal's cage unless specified by the principal investigator.

TABLE 2

Temporary Enrichment Devices

non-food devices	**food (covered) devices**
nylar ball, small	device with food covering
gumma ball	nylar ball, small, large
gumma ring	gumma ball
gumma pull	gumma ring
gumma knot	gumma pull
dental knot	gumma knot
Kong toy	grenade
dumbbell (colorburst)	Kong toy
fling a ring (colorburst)	dumbbell (colorburst)
solid vinyl ball (colorburst)	fling-a-ring (colorburst)
grenade	solid vinyl ball (colorburst)
stuffed animals	contains solid or liquid food items
toggle bolts, large	raisin ball with chain, or without
hair brush	Kong toy with jello, or frozen juice
	seed feeder
	food sock

Permanent Foraging Devices

The search for food is the predominate activity of free ranging primates (Bayne, 1989). Several processes are involved in foraging. The majority of each day is spent traveling through their range searching for and harvesting food (Lindburg, 1991). An enrichment provides the nonhuman primate with an opportunity to perform these behaviors. Searching behaviors can be initiated by food hidden in foraging devices. Foraging behaviors can also be produced by feeding foods with an outer covering, such as bananas and oranges, which before being eaten need to be peeled or broken apart. Permanent food devices (Table 3) were reserved for animals displaying abnormal behaviors and/or animals not placed in the SPR chamber because of poor performance. These devices were also used to deliver food items that animals would normally receive in their home cages.

TABLE 3.

Permanent Enrichment Devices

Permanent Non-Food Devices	**Permanent Food Devices**
swing	puzzles (shaker, feeder)
milk carton	foraging box
safety cone	foraging tray
stuffed animal	foraging board
tug rope	foraging tube (peanut butter, crumble)

Foraging Boxes were designed to hold sawdust or bedding mixed with crumbles (Bio Serv, Frenchtown, NJ) or trail mix. The trail mix consisted of small PrimaTreats, unsalted peanuts, and miniature marshmallows. This device could only be attached to the front of the cage. A disadvantage in using this device was that it obstructed the door entrance and prevented attachment of the transport cage which was used daily for movement of the animal.

Puzzle Feeders simulated a more natural environment by encouraging the monkey to search for food. The feeder was a rectangular clear Plexiglas box 30.5 cm high x 15 cm wide x 5 cm deep. The five upper levels of the feeder were made from individual horizontal or vertical pieces of colored Plexiglas. Hundreds of different maze patterns were created by changing the position of the colored pieces. The maze pattern was changed daily depending on the level of efficiency of individual animals. The original feeders were attached to the front of the cage using cable ties. Each day, however, the ties had to be cut to remove the animal from the home cage prior to his operant training. The maze pattern was increased in complexity as the animals became more efficient. After establishing the pattern, foods such as PrimaTreats, peanuts, or golden squares were placed inside the device. The device was secured with a small padlock to prevent the monkeys from taking the puzzle apart. A feeder with an improved design not

requiring a padlock was subsequently purchased. However, these feeders were still difficult to use. Ultimately, the original devices were placed inside the home cage.

Fickle Finger Boards from Bio-Serv were also used as permanent enrichment devices. These foraging devices were securely mounted to the top of the home cages. The boards contained several holes of various sizes. The primates were required to use their fingers to manipulate treats across the board and retrieve the food through the largest holes. The location of the device did not obstruct the door, nor did the device have to be removed to be filled safely or when the home cages were sent through the cage wash.

Foraging Board devices were made of fleece or artificial turf. Pieces of dry food (i.e., Prima Crumbles, Bio-Serv, Frenchtown, NJ) were rubbed into the material. The primates picked through the fibers to remove and consume the particles.

Raisin Board devices (Figure 1F) were constructed from rectangular pieces of Nylar. Small holes were drilled through each board. These devices were filled with shelled peanuts, marshmallows or raisins. The cage doors were unlocked and raised a few inches. When the boards were inserted a few inches into the cages, the primates grabbed the devices and pulled them into the cage. They used their fingers or tongues to work the food loose from the holes. After removing the food particles they usually licked the remaining food off of the boards.

Puzzle Feeder Balls were suspended in the home cage by chains. They held large (5gm) PrimaTreats (Bio-Serv, Frenchtown, NJ). The balls had several size holes cut around the surface. These devices were filled by dropping the treats through a slot in the top of the ball. Only the largest hole would allow removal of the food.

Peanut butter foraging tubes were spring-loaded devices consisting of a long cylinder coated with peanut butter and crumbles placed inside a clear plastic sleeve. This sleeve was open in several locations allowing the animal access to the food. The sleeve coated with food could be moved around within the outer sleeve allowing the animal access to all of the foodstuffs. The device required disassembly and scrubbing by the technicians to remove the old food.

Crumble stick foraging tubes were similar to the Peanut Butter Tube Feeder devices. They were made from clear plastic and contained several slits around the outside. A Crumble Stick (compressed Prima Crumbles in a cylindrical shape) was placed inside the device. The primates picked at the Crumble Stick through the slots in the holder and ate the pieces they were able to break off.

Shaker Puzzles were small, clear plastic cylinders. They contained one small opening in the top. These devices were placed inside the cages. Shaking the devices released food pellets from the small opening.

Permanent Non-foraging Devices

Permanent non-food devices were rotated throughout the colony over a one-to-three week-interval (Table 3). These devices were attached to the home cage. They were usually placed in the home cage or removed from the home cage for cleaning, during the animal's daily SPR training.

Cleaning Enrichment Devices

A dilute Roccal-D (Upjohn Company, Kalamazoo, MI 49001, USA) soaking solution of 1:400 was prepared by mixing 47.2 ml of Roccal-D in 5 gallons (18.9 liters) of tap water. A bucket containing this solution was prepared daily and kept in each colony room. When an enrichment device was removed from a cage, it was placed in the soaking solution for a minimum of 60 min. The enrichment device was removed from the soaking solution, rinsed off, cleaned of gross material, and subsequently placed in the dirty cage wash area for an additional washing with hot water and detergents. The environmental enrichment devices were retrieved from the clean cage wash area each morning and stored in an appropriate location. The devices were examined daily by technicians to insure that they did not present a danger to the monkeys due to chewing damage or rough handling. Items with rough edges or in poor condition were discarded.

Abnormal Behavior

Stereotypic behaviors consisted of the persistent repetition of non-goal directed behaviors. If left unattended, behaviors such as self-mutilation and head-banging could produce life-threatening injuries. When abnormal behaviors (Table 1) were noted, permanent food enrichment devices were made available to these animals. Stereotypic behavior that was not perceived by the technicians to be stress-related was not treated as abnormal behaviors (i.e., spinning prior to entering the transport cage, vocalizing during feeding, shaking home cage before entering the transport cage). Behaviors that were determined to be abnormal were immediately reported to the principal investigator (i.e., self-mutilation, head-banging, eye poking, auto-erotic stimulation). The attending veterinarian was notified if an injury occurred. A written report documenting the incidence of such behaviors was placed in the laboratory notebook. This report included the animal's identification number, the behaviors, individuals contacted, the response (including the response time), treatment and results. A copy of this report was submitted to the principal investigator and placed in the animal's medical record. Detailed notes were maintained in the laboratory notebook. These notes included (1) incidents of abnormal behavior, (2) SPR performance, (3) weight, (4) changes in food consumption or eating behavior, (5) signs of illness, (6) surgeries and/or medical treatments, and (7) effect of enrichment.

To extinguish these destructive abnormal behaviors, permanent food devices were used to promote home cage activity. Results of the effectiveness of the addition of a permanent food device by comparing previous behaviors were also noted in the laboratory notebook.

Evaluation/Results

Social Enrichment (Pair Housing)

To pair house animals, 2 sets of males (4 animals) and a single set of females (2 animals) were used. The females were successfully paired continuously for 1 year, while a single pair of males were paired only on several occasions and for short intervals (15 min.). Grooming behavior occurred only between the female pair.

The male pairing session was successful only as long as one male was dominant and the other submissive. A full contact pairing session was only initiated when a staff veterinarian was available in the event of an emergency. Due to the non-availability of staff veterinarians, the clear Plexiglas panel was used over several weeks after the primates had spent several sessions together in a neutral cage without fighting. Without additional full contact sessions, the dominant/submissive relationship that had been established was disrupted. As a result, the submissive animal became more aggressive and began charging the Plexiglas panel. He performed aggressive behaviors such as displaying his teeth as well as slapping and shaking the cage. Any attempt to remove the solid metal panel that separated the pair resulted in a display of these aggressive behaviors when the panel door was opened even before visual contact was made. Pairing procedures for this pair were terminated six weeks after the initial removal of the stainless steel panel. The second pair sat side by side and attempted to groom each other through the small bore screen. When the grate between the animals was removed, both animals fought with enough intensity to require both animals to be sutured. Due to injuries, male pairing was eliminated from the enrichment plan.

Human/Animal Interactions

The relationship between the SPR-trained animals and the SPR technicians allowed the technicians to be accepted as senior members of the colony. This was accomplished by having only the SPR technicians supply food stuffs. Feeding individually and allowing the animal to choose fruit and biscuits from a bowl reinforced this hierarchy, thus making all the animals subordinate to the technicians as they would be in a free ranging group. This interaction allowed for species appropriate submissive and greeting behaviors that individually caged animals do not otherwise have.

Animals were trained to accept liquids from a squirt bottle and cathater tipped 60 ml syringe. This procedure was used to administer liquid medications and treats such as applesauce. The technician placed the tip of the squirt bottle in the cage and gently squeezed the bottle while the animal drank.

When given trail mix, the SPR primates hand-selected their favorite food from the technician. Most of these animals were very gentle as they delicately picked up the food with their fingers. Some animals were very discriminating in choosing their food. The monkeys also displayed individual preferences for different PrimaTreat flavors.

While in the transport cage, the majority of the animals sat in front of the guillotine door and watched the technicians prepare their SPR chamber. During this time, the animals were exposed to the sounds of other animals who were performing the SPR task.

Permanent Foraging Enrichment Devices

Puzzle feeders promoted foraging behaviors by requiring the primate to be more involved in locating and obtaining its food. The design of several of the enrichment devices presented unique problems. The rhesus monkeys possessed a high level of manual dexterity and many were able to open the locks that closed these devices. After removing the locks, they would break up the

plastic dividers inside the puzzle feeders. Because of the incredible strength of their hands, many of the primates were able to break the food apart (peanuts) inside the feeder and remove it without pushing the item through the maze pattern. To overcome this problem, commercial primate chow was used in the feeder because most of the primates could not break it apart with the tips of their fingers. The animals also held the feeding device in various ways. Some of the animals held the feeder upright with their feet, while others preferred to lay the feeder on the floor of the cage and wedge it into a corner. Frequently, when the feeder was empty, the monkeys sat on the device.

The technician placed the foraging boxes inside the cages. The primates enjoyed using the foraging boxes as perches. The primates also placed smaller devices, such as gumma rings, balls and dental devices, inside the foraging boxes. A disadvantage of the foraging box was that it could not be used with smaller monkeys. One of the smaller male monkeys pushed the box down and over his head and restraining collar. The box was successfully removed. Another disadvantage was that cleaning these devices inside the cages was time-consuming and difficult. Adding corn-cobb bedding or saw dust to the boxes encouraged foraging behaviors, but it also clogged the floor drains.

Foraging boards had the disadvantage of blocking the door and limiting access to the transport cage. Lam et al. (1991) found that his animals often fell asleep after grooming fleece pads; however, this therapeutic effect produced by grooming the fleece was not noted in this study. The major drawback with raisin boards was the number of man-hours required to fill the devices (Moazed, and Wolff, 1989): it took approximately two hours to fill the boards for 32 animals, and the primates, while they enjoyed the boards, emptied them within a few minutes.

The Peanut Butter Tube Feeder was very time consuming to fill, remove, clean, refill and hang. Not all of the primates were successful in using this device. The animals had a difficult time with the Solid Crumble Stick Tube and gave up rapidly or appeared frustrated. The Shaker Puzzles worked well with the females. However, our male adolescents snapped and destroyed the devices with their teeth. The primates devised several methods for holding the Puzzle Feeder Balls stationary in order to work with multiple openings.

Non-Permanent Enrichment Devices

The Kong toys (Figure 1A) were used more often than any of the other items. They are made from natural rubber and are puncture resistant. They were purchased in red and black and in wolf (extra-large) and large sizes. It took up to three months for the animals to wear the Kong toys to half their normal size. At this point the primates placed Nylar balls inside the broken Kong toys.

Orbit Balls and Orbit Dumb Bells (Figure 1B and C) were made of a soft rubber and were well used by the primates. The rhesus monkeys worked relentlessly for several months before wearing down the spaces between the rubber. The balls and dumb bells were small enough for some of the primates to carry with them while they were transported in and out of the SPR chambers. Unlike the Nylar ball, they did not create loud noises as the animals rolled them on the bars, floor and walls of the cages. Unfortunately, this toy is not available.

Nylar balls (Figure 1D) were used by few animals after the first few minutes in the cage. However, during that time the primates rolled them across the floor and walls of the cages.

Some animals picked up the balls and held them close to their bodies. Some of the animals carried the toy into the SPR chamber. A few used the balls to push inside other enrichment devices that were beginning to deteriorate. The amount of time using the Nylar balls was increased by placing the balls on chains outside of the animals home cages (Figure 1G). The swinging balls seemed to attract the primates attention and were manipulated more than balls left in the cage (Ross & Everitt, 1988). Nylar balls, by themselves, were, in general, poor enrichment devices.

Pull toys (Figure 1E) were distributed among the primates. These items were held by the primates until the technician vacated the room, whereupon the primates pushed the pull toys through the bars dropping them onto the floor. If the technician entered the room while the primates were holding the toys over the floor, the primates withdrew the toys into the cage. After a few weeks, the physical position of the technician (facing towards or away from the primates) was the stimuli that initiated or terminated the behavior. Interaction with the primates was performed by holding one end of the pull toy while the primate pulled on the other end. This procedure was only performed as long as the animal was calm and quiet. If the primate became agitated, the procedure was stopped.

Rope toys

The advantage of rope toys is that the primates would groom them when they were first put into their cages. Rope toys had several disadvantages. The primates wrapped the rope around the squeeze bars making the plate inoperative and subsequently the ropes had to be removed. Some animals shredded the ropes, and the pieces would be washed down the floor drains, occasionally clogging them. Also, the ropes were difficult to sanitize. They were soaked in Roccal before going to the cage wash. As a result, they quickly became discolored and took on an unpleasant odor that could not be removed.

Change of Location

Animals that were moved into the top cage position in a rack behaved more aggressively than when they were housed in the lower cages (i.e., more active and vocal). They challenged the animals moved to the lower positions. Animals that displayed atypical behaviors when positioned near the door window were moved to the rear of the colony room.

Conclusion/Discussion

Knowledge of ecological and behavioral requirements as well as appetitive and consummatory response patterns must be considered for each species to develop an effective enrichment plan (Williams, 1996). For nonhuman primates, each enrichment program must be designed to meet the specific needs of the colony. Since not all primate species have the same environmental or dietary requirements, they cannot be treated as a uniform group (Woolverton et al., 1989). Each animal's reaction to the enrichment devices must be assessed. The cost of enrichment (Appendix B) versus the effectiveness of the total program must be evaluated (Bloomsmith et al., 1991).

The time involved preparing and maintaining enrichment devices must be considered along with the usefulness of the devices. Enrichment devices ignored by the primates served no purpose and wasted valuable limited resources. The preferences of each primate must be considered. The staff should observe the reactions of the primates to novel devices to evaluate the usefulness of the devices.

The enrichment program used devices that promoted foraging and grooming behaviors. Foraging toys and boards allowed the primates to engage in behaviors similar to those that occurred in their natural setting (Hayes, 1990, Bayne et al., 1991b). Foraging devices were expensive and used for short periods of time; many (Peanut Butter Tube, Crumble stick holder, Finger Puzzle) were difficult to clean and reassemble. Foraging boxes were the most cost effective food devices. Even after the food was removed, they were used as perches or as containers to hold the smaller enrichment devices. When the Puzzle Feeders were emptied some nonhuman primates attempted to disassemble them. However, most foraging devices were only used until they were emptied.

Kong toys were also very cost effective devices. They had high usage among the nonhuman primates, the toys could be obtained easily from several different sources and they were reasonably inexpensive. An advantage of the Kong toy was that it could be filled with treats or plugged, or filled with liquid and placed in the freezer for later use. These items could also be suspended from chains within the cage. The nonhuman primates chewed and manipulated these items for several months before destroying them. The quantity of time chewing, examining and slowly destroying the rubber made these toys ideal. A toy that cannot be eventually broken will not maintain the interest of the primate. However, due to their substantial cost, enrichment items should be strong enough to last for a minimum of a few months. Schapiro et al. (1991) recommended allowing the primates to choose between destructible and indestructible manipulative devices. Kong toys held the nonhuman primates' interest without having to use food that would have altered their daily caloric intake. These toys were light and could be carried by the technician. They could be cleaned in the tunnel washer or cage washer without damage. These toys could be stored easily and did not require large quantities of shelf space.

Line (1987) found that only ten percent of a colony of 148 rhesus monkeys paid attention to hard nylon balls after eleven months. None of the 33 cynomolgus macaques in his study used the toys. Bayne (1989) noted that the Nylar balls were ignored by the primates until the technician attempted to remove the toy from the home cage. Other than the initial interest in a novel item, the nylon ball by itself received little attention until a Kong toy was worn down allowing the circumference of the opening at the bottom of the toy to expand. This opening allowed for placement of the nylon ball in the center of it. The placement of the nylon balls on chains outside the cage caused the animals to pay more attention to the nylon ball.

The hard (Nylar balls) and soft (pull toys) nylon toys needed to be rotated daily or they were ignored by the nonhuman primates. These items were inexpensive as well as easy to clean and store, but they were not used throughout the day. Pull toys were only used in the presence of the technician.

The nonhuman primates used the Rope toys to wedge in the squeeze plates. Consequently ropes had to be cut out of the cage. As already described, once the ropes were soiled they were

difficult to clean, even with repeated soaking and washing, and debris from them clogged the floor drains. These Rope toys are no longer used.

The purpose of the environmental enrichment plan is to provide for the psychological well-being of non-human primates. An effective enrichment plan improves the psychological and behavioral health of the primates. An enrichment program provides the biomedical research community with a more refined animal model (Bayne et al., 1991a).

Each plan should incorporate devices that require the use of all the senses: tactile, visual, olfactory, auditory and gustatory (Mahoney, 1992). The devices must also promote foraging, grooming and locomotor behaviors. The program should be evaluated by examining the physical health, behavioral repertoire, stress and coping skills of the primates (Novak & Suomi, 1991). An effective enrichment plan requires the coordination and joint effort of the investigators, veterinarians, technicians, and caretaker staff.

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Appendix A

Criteria of Psychological Well-Being Proposed by Novak and Suomi (1988)

Physical Health	**Behavioral Repertoire**	**Stress**	**Coping**
coat condition - sparse, patchy, full	reproductive success	plasma cortisol	responsiveness to environmental events
eye condition- swelling, crusts, clear, opaque	reproductive behavior	natural killer-cell count	experimental challenges
alertness	fertility	clinical signs	appropriateness of the response
gait pattern- shuffling, limping, stiff walk, normal	prenatal adequacy	grimaces	ability to return to a baseline level of functioning
appetite	parturition	hunched body posture	animal's resiliency
body weight	parental care	abnormal breathing	
growth rate, aging	facial expressions	changes in affective state	
skin-flakes, scaly, rashes, smooth	locomotion		
blood profile, hormones in blood, urine, feces	exploration		
immune function	body postures		
	play		

Appendix B

Cost of devices

Enrichment Devices	Qty	price	Enrichment Devices	Qty	price
Grooved hard dumbbell	ea	3.77	Nylabone - Regular	ea	1.80
Zoomgroom - Firm	ea	4.75	Nylaball - Regular	ea	3.89
Wobbler-Medium	ea	3.25	Nylabone Wishbone- Reg.	ea	2.59
Red Apple Toy	ea	21.00	Gumabone Wishbone-Reg.	ea	3.25
Dental Ball - Giant	ea	5.26	Gumaball - Regular	ea	3.78
Chop Chewy- Large	cs	39.84	Plaque Attacker - Regular	ea	3.25
Chop Chewy - Medium	cs	66.48	PlaqueAttacker Dental Ball	ea	5.50
Chop Chewy Bone - Large	cs	74.40	Kong - Large, Red	ea	4.40
Chop Chewy Bone-Medium	cs	113.28	Kong - Large, Black	ea	4.60
Prima - Challenger Ball	ea	47.30	Kong - Medium, Red	ea	3.89
Prima Crumble StickHolder	ea	45.00	Kong - Small	ea	2.54
Prima Crumble Stick	pk	102.00	King Kong - Red	ea	7.96
Fickle Finger Board	ea	79.00	King Kong - Black	ea	7.96
Challenger - Heavy Duty	ea	32.00	Prima - Forager Box	ea	22.85
Bobbin - 12" Diameter	ea	30.00	Astroturf Tray	ea	14.90
Monkey Shine Mirror	ea	20.00	Chain Assembly	ea	10.25
Plaque Attacker Wolf	ea	5.15	Guma Knot Small	ea	5.35
Plaque Attacker Giant	ea	6.45	Guma Knot Large	ea	10.45
Plaque Attacker Super	ea	7.59	Gumabone Tug Toy	ea	6.95

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